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# The FIM<sup>®</sup> instrument to identify patients at risk of falling in geriatric wards: a 10-year retrospective study

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## Abstract

**Objectives:** the main objective was to evaluate if the admission functional independence measure (FIM<sup>®</sup>) score could be used to predict the risk of falls in geriatric inpatients.

**Design:** a 10-year retrospective study was performed.

**Setting:** the study was conducted in a 298-bed geriatric teaching hospital in Geneva, Switzerland.

**Subjects:** all patients discharged from the hospital from 1 January 1997 to 31 December 2006 were selected.

**Main outcome measures:** measures used were FIM<sup>®</sup> scores at admission using the FIM<sup>®</sup> instrument and number of falls extracted from the institution's fall report forms.

**Results:** during the study period, there were 23,966 hospital stays. A total of 8,254 falls occurred. Of these, 7,995 falls were linked to 4,651 stays. Falls were recorded in 19.4% of hospital stays, with a mean incidence of 7.84 falls per 1,000 patients-days. Although there was a statistically significant relationship between total FIM<sup>®</sup> score, its subscales, and the risk of falling, the sensitivity, specificity, positive predictive value and negative predictive value obtained with receiver operating characteristic curves were insufficient to permit fall prediction. This might be due in part to a non-linear relationship between FIM<sup>®</sup> score and fall risk.

**Conclusion:** in this study, the FIM<sup>®</sup> instrument was found to be unable to predict risk of falls in general geriatric wards.

**Keywords:** *accidental falls, aged, inpatients, FIM<sup>®</sup> instrument, elderly*

## Introduction

In the past years, the prevention of falls in older people has become the focus of much attention. Indeed, the subject was the most read of the Cochrane Library reviews in 2007 [1]. Although it is now known that reducing fall incidence in community-dwelling elderly people is possible, it is still a matter of debate if this can also be achieved in hospitals [2–5]. Nonetheless, several prospective studies have shown a reduction in the number of falls for inpatients after implementation of fall prevention programmes [6–8]. One of the main difficulties to achieve this goal is the lack of a well-established, reliable prediction tool to identify the patients at risk of falling, who will most benefit from preventive measures [9–11]. A few studies, mostly in the field of rehabilitation medicine, have tried to assess the relationships between functional independence measure (FIM)<sup>®</sup> score and the risk of falls, and all of them found a positive association [12–16]. In the most recent work, Lee and Stokic concluded that 'several domains of the FIM instrument showed a good prognostic value in predicting falls', but without giving details on sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV) [16]. In this study, we intended to determine if FIM<sup>®</sup> score at admission was also related to fall risk in geriatric inpatients and if it could be used as a fall prediction tool in this setting.

## Methods

### Study design

This is a 10-year retrospective study conducted in a 298-bed teaching geriatric hospital in Geneva, Switzerland, divided into general geriatrics and rehabilitation. FIM<sup>®</sup> scores are recorded by nurses during the first days of patients' admission and a second time before discharge. The data regarding falls were extracted from our institution's incident forms, which are obligatory after every fall.

We selected all patients discharged from the hospital from 1 January 1997 to 31 December 2006 from the hospital

administrative information system, except those who were later transferred to the palliative care unit, because of the possibility that they would represent a bias, with both low FIM<sup>®</sup> scores and low risk of falls. By considering discharges instead of admissions, we ensured that at the end of the study period we did not consider incomplete stays. Data on falls and FIM<sup>®</sup> scores were then merged with these hospital stays. For patients admitted before 1997, previous FIM<sup>®</sup> scores and fall reports were recovered. Using this data set, we analysed fall incidence, number of falls per stay and relationship with age, sex and length of stay (LOS). Finally, we conducted the statistical analysis for the main objective of the study, the relationship between fall risk and FIM<sup>®</sup> score.

### The FIM<sup>®</sup> instrument

The FIM<sup>®</sup> score was designed in the 1980s to measure outcomes in rehabilitation medicine. It measures the degree of independence on a sample of 18 activities of daily living ('items'). Thirteen of these items form the motor aspect of the score and five the cognitive aspect. Each item is graded from 1 (complete dependence) to 7 (complete independence). This 7-point scale can also be divided into two ('dependence', 1 to 5 points versus 'independence', 6 to 7 points) or three levels of dependence ('complete dependence' 1 or 2 points, 'modified dependence' 3, 4 or 5 points and 'independence' 6 to 7 points). One of the interests of the FIM<sup>®</sup> instrument in research is that it is known to have good metrological qualities, both in the general population and in geriatric patients [17–20]. The FIM<sup>®</sup> instrument is a trademark of Uniform Data System for Medical Rehabilitation, a division of UBI Foundation Activities, Inc. [21].

### Statistical analysis

Differences in proportions were evaluated with the  $\chi^2$  test or the Fisher exact test. Continuous variables were compared using the Student *t*-test and the Mann–Whitney–Wilcoxon

test. Evolution of proportions with time was quantified with the non-parametric Cuzick's test for trend. Logistic regression analysis and binomial negative regression were used to judge the predictive value of certain parameters, in particular FIM® items on the risk of falling. Receiver operating characteristic (ROC) curves and area under ROC curves analyses were built after determining sensitivity and specificity values for different levels of the FIM® score and its subscales in predicting falls. We considered that sensitivity and specificity would have to be >80% for the score to be useful in clinical practice. The proportion of variance explained by the logistic regression models was assessed using pseudo R squared (pseudo  $R^2$ ), a value above 80% (0.80) being associated with good individual predictive properties. All statistical analyses were performed using Stata v 10.1 (Stata Corporation, College Station, Texas, USA). *P* values below 0.05 were considered statistically significant.

The study received approval from our institution's ethics committee. No external funding was provided.

## Results

### Merging of the three data sets

Using the hospital's computerised records, we identified 23,966 hospital stays during the 10-year period. In the same period, there were 8,254 falls and 15,456 admission FIM® scores. After attributing a sequential number to identify each hospital stay, the merging process was done in three steps: first, falls were merged with hospital stays in a stepwise manner, using preferentially stay's or patient's numbers, or, if this failed, using patient's names. To lessen the possibility of wrong attributions, we verified that the date of each fall was between admission and discharge dates. Second, we used the same process to link FIM® scores and stays. Finally, both files were merged using the sequential hospital stay numbers. The final result of this process may be consulted in Appendix 1 in the supplementary data on the journal website at *Age and Ageing* online. Only 90 falls (1.1%) and 813 FIM® scores (4.7%) were lost during the merging due to unrecoverable identification problems on the paper forms such as missing labels, missing case number and/or mistyped name. The mean age of the population was  $84.3 \pm 7.1$  years, and 70.8% of patients were females.

### Falls

19.41% of patients experienced at least one fall, with a mean incidence of 7.84 falls per 1,000 patients-days. Throughout the study, there was a slight but significant increase in the incidence of falls (increase of 0.22 fall per 1,000 patients-days per year,  $P < 0.001$ ), as shown in Appendix 2 in the supplementary data on the journal website at *Age and Ageing* online. Most fallers (65.0%) suffered only one event, with a mean of 1.68 falls per stay. Fallers were significantly older than non-fallers (85.3 versus 84.2 years,  $P < 0.001$ ), but there was no difference in age between single and multiple

**Table 1.** Differences in sex, mortality, LOS and age for patients with and without FIM scores at admission ( $N = 23,966$ )

	<i>N</i>	% by sex (F/M)	Mortality (%)	LOS <sup>a</sup> (days)	Age <sup>a</sup> $\pm$ SD <sup>b</sup> (years)
FIM+	14,643	62.5/57.6	8.3	43.5	$84.4 \pm 7.0$
FIM-	9,323	37.5/42.4	11.6	41.0	$84.2 \pm 7.1$
<i>P</i>		<0.001	<0.001	<0.001	0.037

<sup>a</sup>Mean.

<sup>b</sup>SD, standard deviation.

fallers. Men fell more frequently than women (22.2% versus 18.5% of hospital stays,  $P < 0.001$ ) and had more falls per stay.

### FIM® scores

Of the 23,966 stays, 14,643 (61.1%) had an admission FIM® score. This percentage rose slowly during the 10-year period, from 52.2 to 81.5% in 2006. The populations with and without FIM® scores were slightly but significantly different. Details are given in Table 1. 76.1% of the scores were complete (18 items), and 99.1% had a maximum of three items missing.

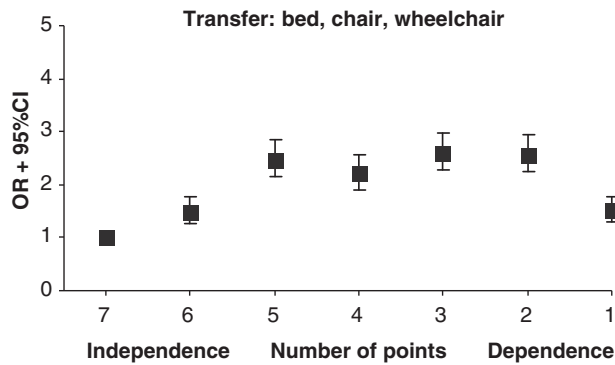
### Relationship between FIM® scores and falls

For this section, we dismissed all FIM® scores with more than three items missing (223 scores, 1.52% of total). To lessen the effect of missing items on total FIM® scores, we used an imputation technique to extrapolate the average score of the completed items to the missing items, giving a projected total FIM® score.

We used the Wilcoxon test and logistic regression analyses to explore the relationships between the admission FIM® score and the risk of falling. We analysed the relationship according to the seven discrete points, by regrouping the score into two levels and finally three levels of independence, as defined in the method section. For each item, we found a positive relationship between low scores and the risk of falling, with odds ratios (OR) between 1.0 and 3.7, but pseudo  $R^2$  values (an estimate of the proportion of variance explained by the model) reached only a maximum of 2%. A striking observation is that the risk of falling does not augment continuously with the decrease of the score. Indeed, for all items, the risk even regresses at higher degrees of dependence. An example is shown in Figure 1.

Mean FIM® scores were significantly different between non-fallers, single and multiple fallers: the total score was  $83.4 \pm 28.7$  in patients who did not fall,  $75.1 \pm 25.5$  in single fallers and  $70.1 \pm 24.4$  in multiple fallers.

The results of multiple regression analyses for the total FIM® score and its motor and cognitive aspects on the risk of falling are shown in Appendix 3 in the supplementary data on the journal website at *Age and Ageing* online.



**Figure 1.** Risk of fall, OR and 95% confidence interval (CI) for item 9: transfer (bed, chair, wheelchair).

We used ROC curves analyses to determine which cut-off score produced the optimum sum of sensitivity plus specificity, first taking into account all points of the curve (1-point increments) and then as a binary model (i.e. strictly superior to the cut-off score). For total FIM<sup>®</sup> score, the best values were obtained with a threshold of 80 points: sensitivity and specificity were both 41.6%. PPV was 15.2% and NPV was 73.9%. With a threshold of 90 points, sensitivity dropped to 29.2% for a modest gain in specificity (51.9%). PPV and NPV were 13.2 and 74.5%, respectively. Concerning the motor aspect, the cut-off value was determined at 55/91 points. In the binary analysis, sensitivity was 41.4%, specificity 43.3%, PPV 15.5% and NPV 74.7%. Concerning the cognitive aspect, the maximum sensitivity–specificity threshold was 26/35 points. The sensitivity was 37.5%, specificity 44.7%, PPV 14.6% and NPV 74.0%. The ROC curves for the total FIM<sup>®</sup> score and its motor and cognitive aspects are shown in Figure 2.

## Discussion

### Strengths and limitations

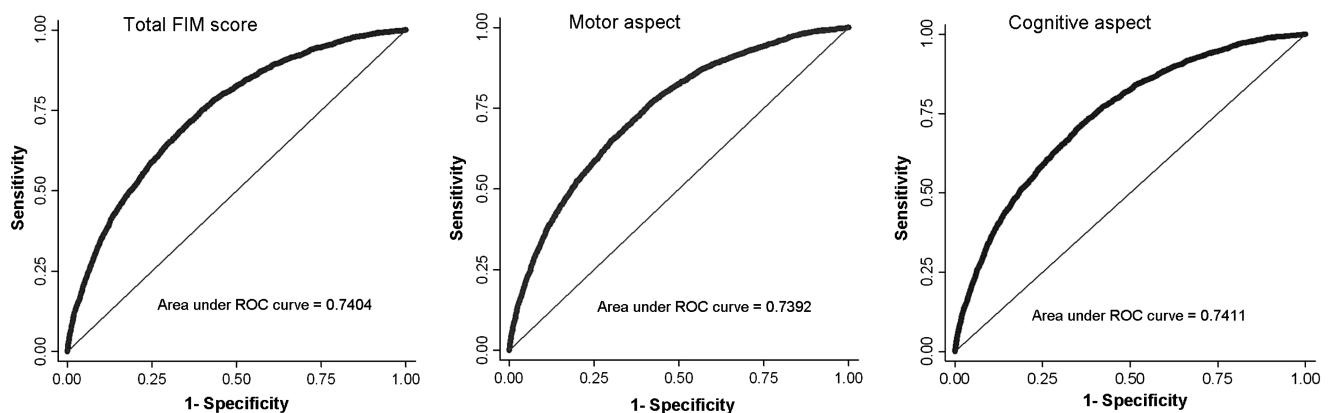
The strengths of this study are the length of data collection and, consequently, the significant number of patients and falls included, giving it a great statistical power.

A weakness of our study is the low prevalence of FIM<sup>®</sup> scores at admission, with a mean of 61%. However, this number rises slowly with time, reaching 81.5% the last year of the study. Also, there was a statistically significant difference between patients with and without FIM<sup>®</sup> scores at admission. The difference in age (0.2%) is unlikely to have any repercussion on statistical analyses. The longer LOS (5.8% longer in patients with FIM<sup>®</sup> score) is probably related to the fact that there is less time to do the FIM<sup>®</sup> score for patients with very short stays (for example, patients who were transferred out or died on the day of admission). The higher mortality rate might reflect the little value of having FIM<sup>®</sup> scores for patients with poor prognosis or hospitalised for palliative care. The reason for a lower rate of FIM<sup>®</sup> score completion in men is less clear. Thus, it is possible that some patients are under-represented in this study, but given the size of the sample, we feel this is unlikely to have changed the results of the study. Moreover, it would be very surprising that the FIM<sup>®</sup> score would have such improved predictive values in these patients that it could be used to predict falls.

Finally, there was some loss of information when data on falls and FIM<sup>®</sup> scores were merged with the records. This problem, inherent to retrospective studies, is mainly due in this case to different computerised administrative systems being used during the 10-year period, in particular different ways of identifying patients. Secondly, information on FIM<sup>®</sup> scores and incident forms were sometimes accidentally modified during scanning. The loss of falls is low (1.1%), and the loss of FIM<sup>®</sup> scores is acceptable (4.7%). The last year of the study, the loss is 0% for both, as FIM<sup>®</sup> scores and incident forms are now entered directly in the patients' computerised medical record.

### Falls — comparison with previous studies

In our study, the proportion of patients who fell (19.4%) is in the range that has been previously reported for geriatric inpatients, but the incidence of falls is slightly lower [7, 22, 23]. The finding of a progression of the incidence of falls is



**Figure 2.** ROC curves for total FIM score and its motor and cognitive aspects.

worrying, and no clear cause has been found. It could reflect a higher rate of falls being reported each year, or be the consequence of the increase in the mean age of patients or more dependant patients being admitted. The fact that age, male sex and LOS are associated with higher fall risk is also concordant with previous studies. However, concerning LOS, a Kaplan–Meyer curve analysis adjusted for LOS showed that falls occur at random during the stay. It appears thus possible that, contrary to what is generally thought, falls are not a strong risk factor for longer LOS, but instead longer LOS could be merely seen as ‘more time to fall’.

### Relationship between FIM<sup>®</sup> score and falls

Our study confirms the existence of a relationship between the admission FIM<sup>®</sup> score and the risk of falling. The number of cases studied allows us to show that this is true not only for the total score but also for each of its aspects, subscales and items. However, this relationship is insufficient to permit the use of the FIM<sup>®</sup> instrument to predict an individual risk of falls. In logistic regression models, OR for falls never exceed 3.5 and pseudo  $R^2$  values are low. ROC curves analyses for total FIM<sup>®</sup> score and its motor and cognitive aspects show that sensitivity, specificity, PPV and NPV are clearly insufficient to permit fall prediction, despite what was suggested in previous studies [12, 16]. However, these studies were conducted in the field of rehabilitation medicine, and it is possible that risk factors for falls are not the same in this setting.

This study is also in concordance with previous works showing a non-linear relationship between FIM<sup>®</sup> score and fall risk [12, 13, 16]. This non-linear relationship can be interpreted as follows: independent patients enjoy a reduced risk of falls albeit not null, as performances decrease the risk of falls raises up to a point where the patient's dependency is so high that they stay in bed or in an armchair and thus decrease their risk of falls. This is likely to contribute to the poor predictive performance of the FIM<sup>®</sup> instrument, and it is possible that other ‘functional’ fall assessment tools will show comparative results.

### Conclusions

In this study, unique by its size, FIM<sup>®</sup> score at admission was shown to be a poor predictor of the individual risk of falling in geriatric inpatients. Research must turn to other fall prediction tools like walk analysis under double tasks [24, 25], applying ‘Gold Standard Criteria’ as stressed by previous authors [10, 11, 26]. In particular, sensitivity, specificity, PPV and NPV should always be provided, to avoid the multiplication of inconclusive studies appealing to ‘more research’.

### Key points

- No fall-risk assessment tool has shown sufficient performance to be widely recommended for use in hospitals.

- There is a relationship between the FIM<sup>®</sup> score and the risk of falling, but this relationship is non-linear.
- The FIM<sup>®</sup> instrument cannot be used to predict risk of falls in general geriatric wards.

### Conflicts of interest

The authors report no conflict of interest.

### Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

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# Handgrip strength as a predictor of functional, psychological and social health. A prospective population-based study among the oldest old

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## Abstract

**Background:** muscle wasting is associated with a detrimental outcome in older people. Muscle strength measurements could be useful as part of a clinical evaluation of oldest old patients to determine who are most at risk of accelerated decline in the near future.

**Objective:** this study aimed to assess if handgrip strength predicts changes in functional, psychological and social health among oldest old.

**Design:** the Leiden 85-plus Study is a prospective population-based follow-up study.

**Subjects:** five-hundred fifty-five, all aged 85 years at baseline, participated in the study.